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has always seemed to me very important; viz., whether the light of the corona contains an important proportion of solar light. The result surpassed my expectation in this matter. The Fraunhofer spectrum, so complete as I witnessed it at Caroline Island, proves, that, without denying that a certain part is due to diffraction, there exists in the corona, and especially in certain parts of the corona, an enormous quantity of reflected light; and as we know, besides, that the coronal atmosphere is very thin, it must be that in these regions cosmic matter exists in the condition of solid corpuscles, in order to explain this abundance of reflected solar light.

"The more we advance, the more we perceive the complex nature of the regions in the immediate vicinity of the sun; and it is only by persistent and very varied observations, and an exhaustive discussion of these observations, that we can arrive at an exact knowledge of these regions. The great eclipse of 1883 has allowed us to take a step forward.

"*Photography of the corona.* — The result of the studies of the photographs will be given later; for they require a thorough examination, since they record many most interesting phenomena. I will simply say at present, that these photographs show a corona more extended than that given by telescopic examination, and that the phenomenon appeared well defined and steady during the duration of totality.

"*Luminous intensity of the corona.* — I had prepared a photometric measure, by photography, of the luminous intensity of the corona. This experiment showed that at Caroline Island the illumination given by the corona was greater than that of the full moon. The exact numbers will be given later. It should be noted, that this is the first time that an exact measure of the luminous intensity of this phenomenon has been made."

The remainder of the report gives an account of the return journey of the members of the expedition. They visited the volcano of Kilauea on the island of Hawaii, and passed a night in the crater on the edge of the lava lake. Mr. Janssen made some experiments, which, he states, "show some curious coincidences between these volcanic phenomena and those of the solar surface. I was able, also, to obtain the spectrum of the flames which issue from the lava, and to establish in them the presence of sodium, hydrogen, and the carburetted compounds." W. U.

THE HIMALAYAS.[1]

MY predecessor, Sir Richard Temple, selected for the subject of his address to this section last year, 'The central plateau of Asia.' Following him in a measure over some of the same ground, I have selected the mountain region south of the Central Asian highlands, viz., the Himalayas, and more particularly the western portion of that range, as the subject of this paper. I propose considering this mountain chain with reference to its physical features, past and present, and consequently with reference to its geological history, so far as that relates to later tertiary times; i.e., the period immediately preceding the present distribution of seas, land, rivers, and lakes. It is not, however, my intention to enter very deeply into the purely geological branch of the subject.

The Himalayas, the highest mountains in the world, comprise, strictly speaking, only the snowy range seen from the plains of India, bordering upon the course of the Ganges; but we might, I think, use the term in an extended sense, so as to include that which we may call the north-western Himalaya, north of the Punjab, and also the eastern Himalaya, bordering on Assam. The orography of this mountain mass has been recently ably handled by Messrs. Medlicott and Blanford;[1] and I follow them in all their main divisions and nomenclature, which are based upon a thorough understanding of the rocks of the country. Some line must be selected where the term 'Himalaya' must cease to be used, and this cannot be better defined than by the valley of the Indus from Attock to Bunji. On this line we find the great bending-round of all the ranges. To the mountains north of the Indus, on its east and west course, the name 'Himalaya' should certainly never be applied. For this north-west, trans-Indus part of the Asian chain we have the well-known name 'Mustagh,' so far as the head of the Gilgit valley; the 'Hindu Kush' being an excellent term now in common use for its extension to the Afghan country.

The observations made by many of the assistants of the Indian geological survey, more especially by Stoliczka, and more recently by Lydekker, in the Himalayas, combined with those made by myself in the same region, have, when considered in conjunction with the ascertained strike of the granitoid or gneissic rocks, led me to separate the great Central Asian chain into the following five principal divisions, with some minor subdivisions: —

1. The main or Central Asian axis, Kuenlun.
2. Trans-Himalaya.
3. Himalaya.
4. Outer or lower Himalaya.
5. Sub-Himalaya.

In our present ignorance as to the composition of the chain eastward from the Sutlej, we cannot attempt to lay down there any axis-lines of original elevation; but the separation of the line of highest peaks into one range, and the water-parting into another, is an acceptable solution of the physical features, as at present known, of this part of the chain. I think, however, that when this ground is examined, it will resolve itself into a series of parallel ridges, more or less close, and oblique to the line of greatest altitude as defined by the line of high peaks, crossing diagonally even the main drainage-line of the Sanspu; just as we see the Ladak axis crossing the Indus near Hanlé, or the Pir Panjal that of the Jhelum. Sir Henry Strachey's conception of the general structure was the soundest and most scientific first propounded.

[1] Abstract of an address by Lieut.-Col. H. H. GODWIN-AUSTEN, F.R.S., F.G.S., F.R.G.S., etc., president of the section of geography of the British association.

[1] A manual of the geology of India, 1879, p. 9.

He considered it to be made up of a series of parallel ranges running in an oblique line to the general direction of the whole mass, the great peaks being on terminal butt-ends of the successive parallel ranges; the watershed following the lowest parts of the ridges, and the drainage crossing the highest, in deep gorges directly transverse to the main lines of elevation.

We can, in a measure, exemplify the structure of the Himalaya by that of the bones of the right hand, with fingers much elongated and stretched wide apart, of which the wrist and back may represent the broader belt of granitic rocks of the eastern area; the thumb and fingers, the more or less continuous ridges of the north-west, some less prolonged than others to the north-west, such as the Chor axis, which may be represented by the thumb, terminating on the southern margin near the Sutlej. The left hand placed opposite will represent the same features to the west of the Indus. We will even carry this simile farther, and, as a rough illustration, suppose the intervals or long basins between the fingers to be filled with sedimentary deposits, and the fingers then to be brought closer together, producing a crushing and crumpling of the strata. At the same time, an elevation or depression, first of one or more of the fingers, then of another or of the whole hand, has taken place, and you are presented with very much what has gone on, upon a grand scale, over this vast area. As these changes of level have not taken place along the whole range from east to west in an equal extent, but upon certain transverse or diagonal lines, undulations more or less great have been the result; and some formations have attained a higher position in some places than in others, producing, very early in the history of these mountains, a transverse system of drainage-lines, leading through the long axial ridges.

The last efforts of these rising, sinking, and lateral crushing, and, as I believe, very slowly acting forces, are to be seen at the southern face of these mountains, in the tertiary strata that make up the sub-Himalayan axis (Sivalik), — a topographical feature which is most striking by reason of its persistence and uniformity for some 1,600 miles. From Assam on the east, to the Punjab on the west, bending round and extending to Scinde, this fringing line of parallel ridges is found at the base of the Himalayas, sometimes higher, sometimes wider, often forming elliptical valleys. Only in one part of the belt, east of the Teesta, are they absent altogether for a distance of fifty miles. These formations are of vast thickness, and, in the Punjab, cover an area of 13,000 square miles. The whole of this material has been derived from the adjacent Himalayas, and has travelled down valleys that have been excavated in pre-tertiary times. This points to a slow subsidence of the whole southern side of the mountain mass, deposition generally keeping pace with it, broken off by recurring long intervals of re-elevation.

The next most interesting feature connected with the former distribution of land and sea is that these sub-Himalayan formations are fresh-water, or torrential, showing that since nummulitic or eocene times the sea has never washed the base of the Himalayas. In fact, there is no evidence of this from the gorge where the Ganges leaves the mountains up to the base of the Garo Hills. I believe that from Assam to Scinde there once existed a great river, receiving its tributaries from the Himalayas, partly a land of lakes and marshes, the home of that wonderful mammalian and reptilian fauna which Cautley and Falconer were the first to bring to light. The southern boundary of this long alluvial plain was formed by the present peninsula of India, and probably of the extension of the Garo and Khasi Hills westward to the Rajmahal Hills. Depression has been considerable in the neighborhood of Calcutta, nearly five hundred feet. At three hundred and eighty feet, beds of peat were passed through in boring; and the lowest beds contained fresh-water shells. The beds, also, were of such a gravelly nature as to indicate the neighborhood of hills, now buried beneath the Ganges alluvium. This is precisely the appearance of the country above Calcutta, on approaching the present valley of the Brahmaputra. The western termination of the Garo Hills sinks into these later alluvial deposits; and along the southern face of the range, up to Sylhet, the waters of the marshes during the rainy season wash the nummulitic rocks like an inland sea, and point to the very recent depression of all this area. The isolated granite hilltops jutting up out of the marshy country from Dhoobri to Gwalpara, and on to Tezpur, all testify to the same continuous depression here. It is exactly north of this that we find the Sivalik formations, absent at the base of the Himalayas.

This gradual depression of the delta of the Ganges, the relative higher level of the water parting and shifting of the Punjab rivers westward, appear to be only the last phase of that post-pliocene disturbance which broke up the Assam sub-Himalayan lacustrine system draining into the Arabian Sea. Zoölogical evidence, which I cannot here find space to quote, is also in favor of this former connection of the now separated waters of the Ganges and Indus basins, and the hill-tracts of the Garo and Khasi Hills with peninsular India.

Within the mountains in the old rock basins — and these are analogous to the valleys of the Alps — are pliocene and post-pliocene beds of great thickness, but of fresh-water origin; the remnants of which are to be seen in Kashmir and Scardo at intervals, along the valley of the Indus, and that large, now elevated, accumulation at the head of the Sutlej River in Hundes, — all in the more sheltered portions of the valley basins, untouched by the denuding action during the glacial period. The extent and displacement of the upper pliocene beds in north Italy and here are very similar. Often abutting horizontally against the mountains, they are in other places found tilted at considerable angles on the margin of their original extension. When we examine their contents, we find that the fauna of that time, in Asia as well as Europe, was more African in character, and included the hippopotamus, crocodiles, and tortoises; of which, the common crocodile, the gavial or long-snouted species, and an Emys,

have survived the many geological changes, and still inhabit the rivers and low grounds of India to-day. The fresh-water shells are the same now as then. Many species of antelope lived in the neighboring plains and uplands. The elephant was there in the zenith of its existence, for no less than thirteen species have been found fossil in northern India.

If we now turn to Europe to compare formations of similar age, Lombardy and the valley of the Po, with the southern side of the Alps, present to us somewhat similar physical features. A large area of about the size of the north-west Punjab, once a part of the miocene sea, is occupied by a remnant of rocks of that age, considerably elevated and tilted, but not to such an extent as those of the Himalayas. Near Turin these dip towards the mountains; and a very short examination shows the undoubted glacial character of some of the beds; and, as the whole formation is marine, their large sharply angular material, much of which is jurassic limestone, was probably transported from the adjacent mountains by the agency of ice in a narrow sea.[1] After the great crushing and alteration of the previous outlines of the whole country, another sea filled the basin of the Po, and pliocene deposits were laid down in a sinking area extending to the base of the mountains all round the new bay or gulf. Re-elevation again set in, and with it, or soon after it, the advent of another and the last glacial period.

Before the last great elevation of the alpine chain, the whole line of seacoast, therefore, ran even high up the long deep valleys of Maggiore, Como, Garda, etc. Then came the gradual but uneven elevation of the whole area, including the miocene hills south of the Po; and lacustrine and estuary conditions prevailed over much of the plain country. The lapse of time was probably enormous; and, as the land rose and the sea retired, the climate gradually became cooler, and ushered in the glacial period. With the change and the increased volume of the mountain torrents, the destruction of the upraised marine pliocene beds commenced, and finally culminated in the extreme extension of the glaciers, even into the plains. The denudation of this formation has been enormous along the base of the Alps, and only mere remnants are to be found. Their preservation is due to their being in position where the great denuding force, the ice, has been unable to touch them: in other instances the early deposition of moraine matter upon them has acted liked a shield, and prevented their entire destruction.

The scattered remnants of the pliocene formation south of the Alps show well how soon a great formation may be completely destroyed by denuding forces.

[1] No trace has been observed of this glacial period in the miocene of India. The most lofty portions of the chain had not then attained a greater elevation, probably, than 14,000 to 18,000 feet, and the outer axis-lines far less. However, in the tertiary beds (middle eocene?) of the Indus valley, below Leh, such conditions are indicated by Lydekker (*Memoirs of geological survey of India*, vol. xxii. p. 104, which I have received since this address was sent to press).

It is an established fact, that the great valleys of the Alps and Himalaya existed much in their present form during miocene times; and they may owe their excavation partly to the glacial action of that period, when these mountain slopes rose from the plain or margin of the ancient sea, far in front of the present line of slope, and were far higher than now.

It is not improbable, that, during the earlier extension of the glaciers into the Maggiore basin, the sea still had access to it. This would have greatly aided in the removal of the marine deposits, and then the deeper erosion of its bed near the Borromean Islands, so well put forward by Sir Andrew Ramsay. When we see the gigantic scouring which glaciers have effected in the hardest rocks on the sides and bottoms of valleys, when we know for certain the enormous thickness they reached in the Alps, I do not doubt for a moment their capability of deepening a rock basin very considerably, or their power to move forward over and against slopes so low as 2° to 3°.[1]

Passing from the glacial action displayed in the outer Alps to that in the Himalaya, we find ample evidence of a period of great extension of such conditions, first in the erratics of the Attock plain and the Potwar, lying fifty to sixty miles from the gorge of the Indus at Torbela. We have again the fact that in Baltistan, in the Indus valley, glaciers have twice descended far beyond their present limits, first down to Scardo itself, and then to some thirty miles below their present limits; while the glaciers of Nanga Purbet, towering above the Indus some 22,000 feet, must have descended into the bed of that river.

In fact, examples of the former extension of glaciers are wide-spread along the chain of the Himalayas from west to east. True moraines and moraine-mounds, at 16,000 feet on the north side of the Baralasa Pass, attest the presence of glaciers on the elevated plain of Rukshu, where now the snow-line is over 20,000 feet. Drew gives much valuable information regarding their former size. On the east, in Sikkim, Sir Joseph Hooker has described moraines of great height (700 feet) and extent. Still farther south and east, in the Naga Hills, a short period of greater cold is indicated by the moraine detritus under the loftiest portion of the Burrail range, in latitude 25° 30′.

Whatever may have been the length of the glacial period in the Alps, — and it was very considerable, — in the Himalayas it cannot have been so long and so general, although to a certain extent contemporaneous.

In the Alps, glaciation meets the eye on every side; and the mountains, up to a distinct level, owe their form and outline to its great and universal extension. In the Himalayas it is difficult to trace polished surfaces or striae markings, even in the neighborhood of the largest glaciers that are now advancing in

[1] There appears to be too great an advocacy, on the one hand, of ice-action having done all the work of denudation; while, on the other, some writers consider this to have been extremely limited. It is the combination of the two forces, I think, that effects so much, and in so different a manner and degree.

full activity. Although of such great length, these Himalayan glaciers could never have reached the enormous thickness which the earlier alpine glaciers attained.

Two periods of glacial extension are clearly defined, separated by a milder interval of climate. During the earlier glacial period the Indus valley was filled with those extensive lacustrine and fluviatile deposits, mixed with large angular *débris*, such as we see at Scardo, which may be coeval with the extreme extension of the alpine erratics, so far as the miocene hills south of Turin.

The second period followed after a long interval of denudation of the same beds, and would correspond with the last extension of the great moraines of Ivrea, Maggiore, Como, etc., followed by a final retreat to nearly present smaller dimensions. Nowhere on the south of the Himalaya do we find valleys presenting any features similar to those of the southern Alps, particularly on the Italian lakes, which are, I believe, the result, in the first place, of marine denudation, succeeded by that of depression, and finally powerful ice-action.

This attempt to bring before you some of the great changes in the geography of Europe and Asia must now be brought to an end. I am only sorry it is not in more able hands than mine to treat it in the manner it deserves, and in better and more eloquent language; but it is a talent given to but few men (sometimes to a Lyell or a Darwin) to explain clearly and in an interesting form the great and gradual changes the surface of the earth has passed through. The study of those changes must create in our minds humble admiration of the great Creator's sublime work, and it is in such a spirit that I now submit for your consideration the subject of this address.

FRENCH GEOGRAPHICAL EXPLORATIONS.[1]

Since the last re-union of our societies, we have seen the complete success of the French expedition to observe the transit of Venus. This phenomenon, important for astronomy, which requires a unity of measurement of the celestial spaces, should also be of interest to geography, for the unity sought is the correct distance of the sun from the earth. We already know the distance of the moon from the earth, about ninety-six thousand leagues, of which I can easily form an idea, as it is the distance I have traversed by land and sea since 1854, the time that I commenced my isthmus travels. "The French expedition sent to foreign parts to observe the transit of Venus has obtained a great and well-earned success, of which they are justly entitled to be proud." So says one of the most eminent French *savants*, Mr. Dumas, who has largely contributed to that success.

It now remains, and it is not the least difficult part of the task, to compare the results obtained, in order to submit to a delicate analysis the infinitesimal differences, which correspond to errors of hundreds of kilometres, in the distance sought. *Savants* have, it is true, more than a century to make use of the observations of 1882; for the phenomenon will not take place again till the year 2004.

At the extreme east of Europe we find in process of execution a work whereby modern science shall again assert her superiority by a success which the ancients gave up. Through the initiative of Gen. Türr, the Isthmus of Corinth is at this moment being cut, which will shorten by about two hundred and fifty kilometres, on an average, the voyage between the eastern and western parts of the north of the Mediterranean. In the course of the present year, the two plains at the side of the Gulf of Aegina and the Bay of Corinth will be cut away, and workmen will attack the solid mass of forty-seven metres, which it is desired to cut away to eight metres below the level of the sea. It is, *in minimo*, the cut of the Isthmus of Panama, the length of which is seventy-three kilometres instead of six kilometres; that is, double the distance between the garden of the Tuileries and the Arc de Triomphe in the Étoile at Paris.

Some distance north of Corinth, there is unfolding another episode of the struggle between these two rival powers, the earth and man. There the work has begun which will transform a marshy lake into fertile plains. In a few years, broad Lake Copaïs will suffer the fate of Lake Fucino, Lake Fessara, Lake de Harlem, and the marsh of Pinsk.

There is still a fourth isthmus to cut. The king of Siam has authorized a survey for a maritime canal on his territory, between the Indian Ocean and the seas of China and Cochin China. The object is to escape the dangerous Strait of Malacca, and gain six hundred leagues from Europe to the extreme east.

In Arabia, Mr. Charles Huber, who two years ago successfully accomplished a mission for the minister of public instruction, has resumed the journey he made so fortunately; but he wishes to proceed farther than at that time he was able. At present he is at Palmyra, copying rare inscriptions; and, this completed, he will set out for Hall, for the Nedjed, and perhaps farther if circumstances favor his energy and firm will. The Arabian peninsula is one of the fields of study where French science has a long standing and very honorable record. We can but hope that Mr. Huber may show himself worthy of his predecessors.

In the extreme east, Cochin China and Tonquin have been most recently explored by the French, and I should like to recount the discoveries of Dr. Néis and Lieut. Saptans at the sources of the Donnaï. The former is at present *en route* for the region which he has already visited. Ethnography and anthropology, which are his special objects of study, will no doubt acquire new information, full and exact, from Dr. Néis's present journey. The study of the ancient civilizations and of epigraphy engages the attention of Capt. Aymonier, who has just finished a fruitful exploration at Cambodia. The parcels recently sent to the museum of the Trocadero testify to the importance of the results gathered by Mr. Aymonier, who is one of the most distinguished, perhaps the most distinguished, representatives of Indo-Chinese

[1] Address by Ferdinand de Lesseps before the geographical congress at Douai. Translated from *Cosmos-les-mondes*, vi. 91, 121.